Nighttime Retrievals of Optically Thick Ice Cloud Properties from MODIS Infrared Radiances at 3.7, 6.7, 11.0 and 12.0 µm: An Artifical Neural Network Approach

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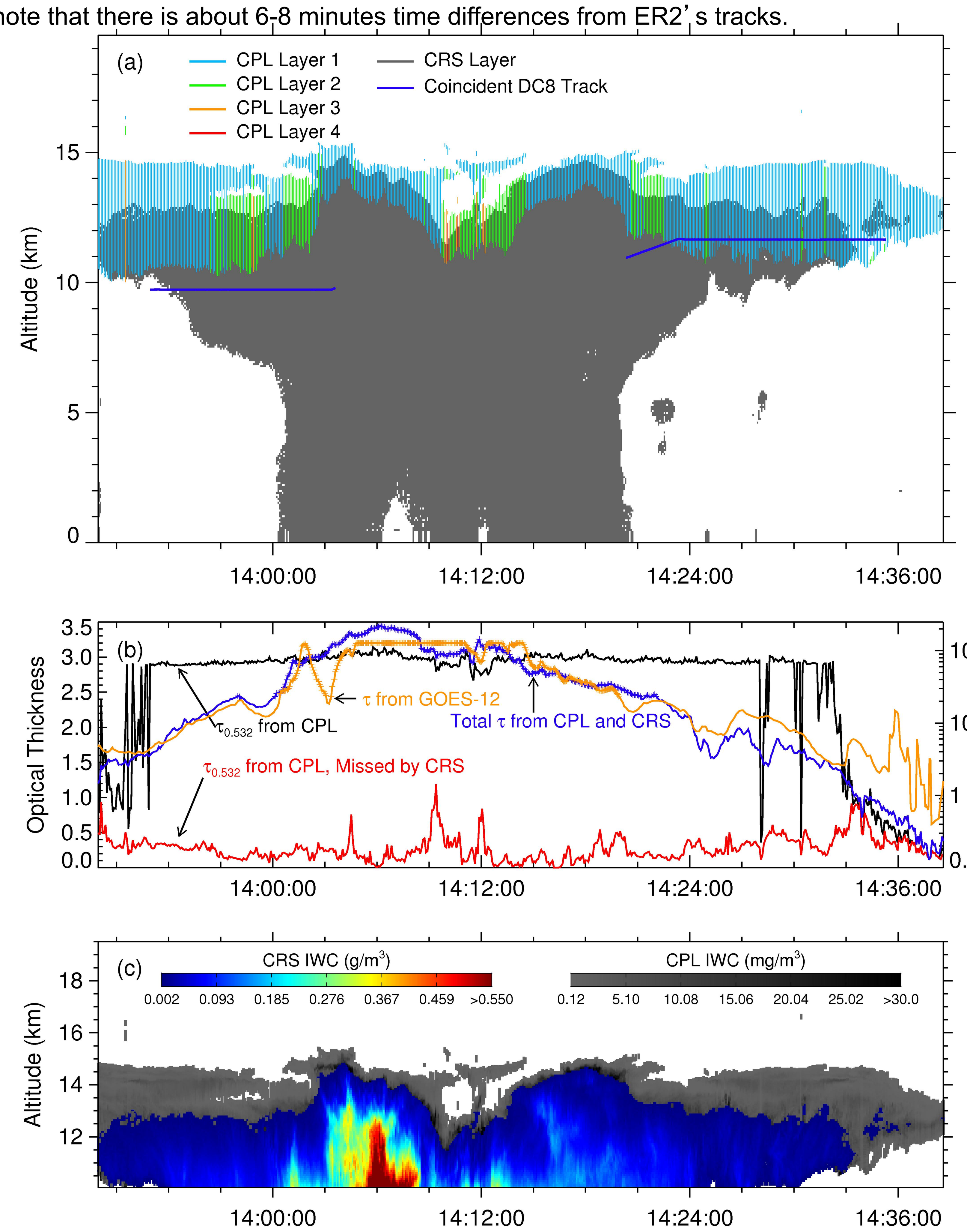
Abstract

Retrieval of ice cloud properties using IR measurements has a distinct advantage over the visible and near-IR techniques by providing consistent data regardless of solar illumination. The IR bands at 3.7, 6.7, 7.3, 8.5, 11.0, and 12.0 µm have been used to infer ice cloud parameters by various methods, but the reliable retrieval of cloud optical thickness (COT) is limited to thin cirrus with a visible COT < 6. The present study investigates the IR radiances at these bands over high thick ice clouds and thereby to investigate the potential of extending the retrieval of COT to thicker ice clouds. The measurements over a deep convective cloud system from the MODIS Airborne Simulator (MAS), Cloud Physics Lidar (CPL), and Cloud Radar System (CRS) aboard the NASA ER-2 aircraft during TC4 experiment on 5 August 2007, are used to investigate the IR radiances over a deep convective cloud system. It is found that the brightness temperature differences among 3.7, 6.7, 7.3 µm and the window bands have sensitivity to higher COTs. Radiative transfer simulations on the basis of the collected *in-situ* measurements show features that are consistent with those of the measurements.

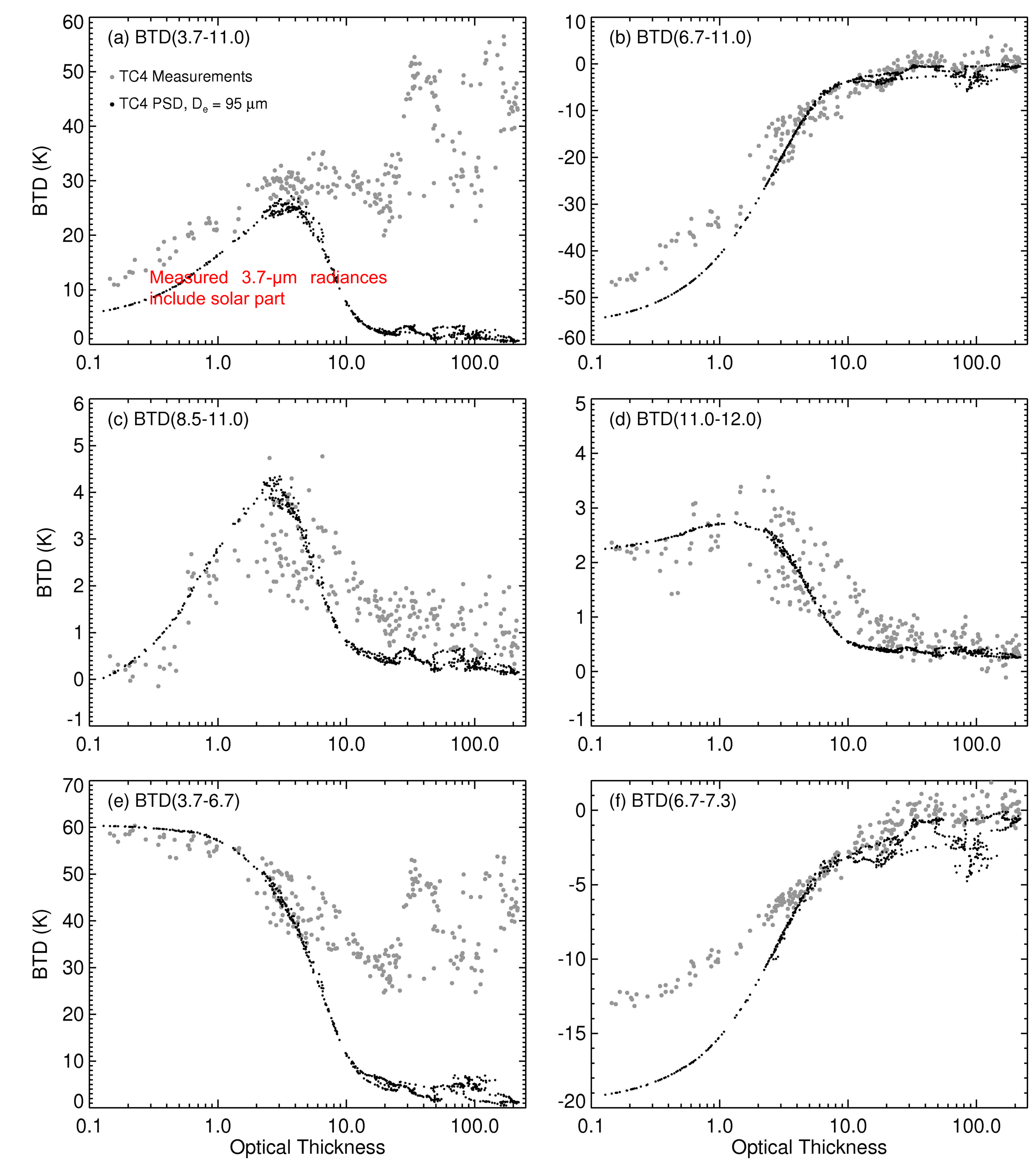
An artificial neural networks (ANN) approach was developed to train IR radiances at MODIS 3.7, 6.7,11.0, and 12.0 µm against CloudSat estimated COT, effective particle size, and cloud-top height during the nighttime for the January to Middle-August 2007 period. The developed ANN approach was applied to the MODIS IR measurements for the rest period of 2007 and then compared to CloudSat measurements. The correlations between ANN estimated COT, effective particle size, and cloud-top height and those from CloudSat measurements are about 0.57, 0.37, and 0.88.

Measurements over a DCC during TC4 on August 5, 2007

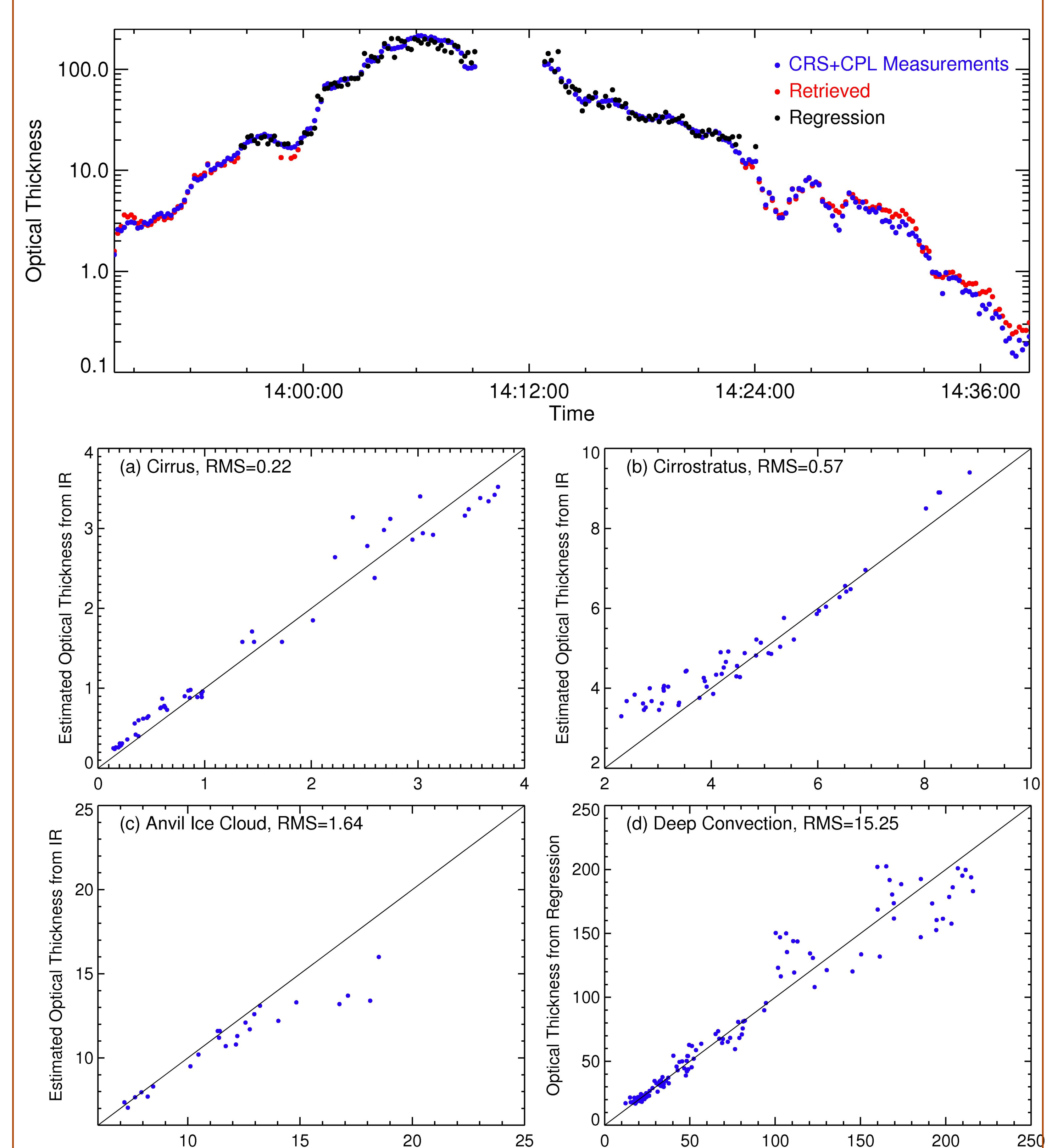
(a) CRS-detected vertical structure of the cloud system and CPL-detected cirrus cloud layers. (b) CPL detected COT of cirrus clouds at 0.532 µm and the part missed by CRS measurements plotted with total COT from CRS and CPL and COT from GOES-12 , (c) constructed CPL ice water content and CRS ice water content above 10 km. The coincident DC8 tracks are shown in (a) and note that there is about 6-8 minutes time differences from ER2's tracks.



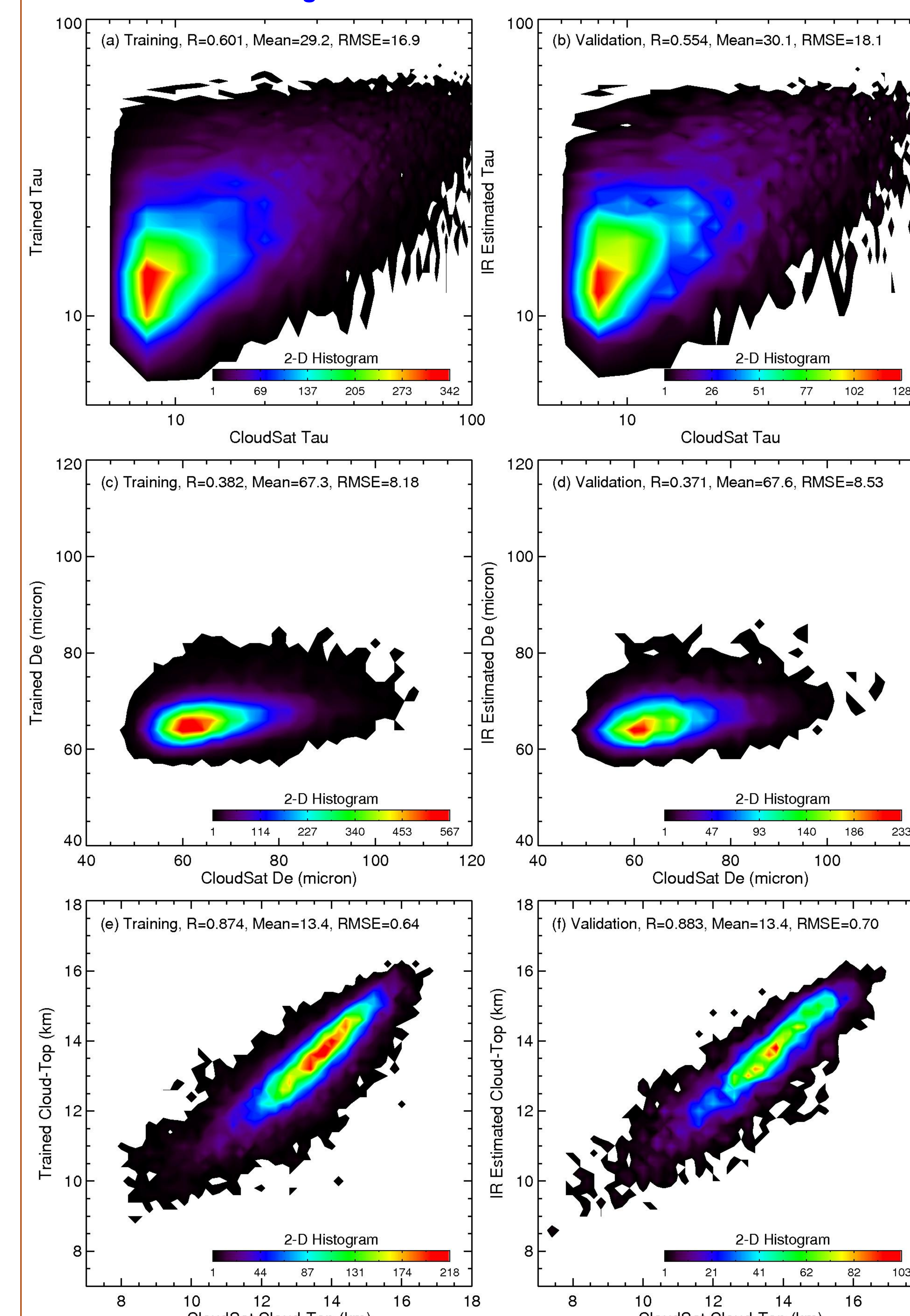
Effect of Ice Cloud Optical Thickness on IR BTDs



A Regression Test for Ice Cloud Optical Thickness



Neural Network Training and Validation



Neural Network Training: collocated MODIS IR and CloudSat data over western pacific warm pool (0-20°N, 140°E-180°E) during 2007 Jan. to Mid-Aug.
Validation: collocate over same area during 2007 Mid-Aug to Dec.

Summary and Discussion

- Both observations and simulations show the potential for combinations of 3.7, 6.7, 11.0 and 12.0 µm to estimate optically thick ice cloud properties.
- An artificial neural network (ANN) approach has been developed to use multiple IR bands to derive COT, effective particle size, and cloud-top height for thick ice clouds. The independent application results agree with CloudSat measurements.
- Further global training using NASA LaRC merged CALIPSO, CloudSat, CERES and MODIS data (C3M).
- Limitation of satellite zenith angle, due to the collocation of MODIS and CloudSat. To solve this limitation, daytime retrieved ice cloud properties using the VISST method will be used for training.

Acknowledgements

The MODIS/ASTER (MASTER) airborne simulator is a joint development involving the Airborne Sensor Facility at the Ames Research Center, the Jet Propulsion Laboratory and the EROS Data Center. The S-HIS data was supported by Dr. H. E. Revercomb. We thank Drs. Lihua Li, L. Tian and G. Heymsfield for help on the CRS data and D. L. Hlavka for help on the CPL data. The CPI and 2DS data were measured by SPEC Inc. The CIP and PIP data were provided by A. Heymsfield. Analysis supported by NOAA GOES-R Program and DOE ARM Program.